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**Using Partial Least Squares Structural Equation Modelling to assess the influence of urban form on travel behaviour**

Urbi Banerjee  
PhD Student  
University of Ulster

Prof. Julian Hine  
Professor  
University of Ulster

Dr. Lisa Davison  
Lecturer  
University of Ulster

**Abstract**

As travel originates from engaging in activities within the urban envelope, we essentially assume that there is an effect of this urban form on the resulting travel patterns. This role of urban form in influencing travel behaviour has been widely researched, but with the multitude of variables involved, there is still a lack of general consensus on the strength and nature of this relationship. Understanding the causality and direction of these interrelationships are of key interest to planners and policy makers as reduction in travel energy consumption is of priority. With increasing concern over climate change issues, policies to effectively target sustainable transport initiatives taking into account the nature and context of the local population is vital. Thus two specific issues are of concern to determine the inter-relationship patterns - firstly '*where we live*' and secondly its impact on '*how we travel*'. This paper addresses these two questions adopting both a substantive and methodological approach. The substantive approach is to warrant a holistic approach to answer the 'how' and 'why' of the relationship between urban form and travel behaviour. For this a two-prong approach involving both a qualitative exploration complimented with an exhaustive quantitative analysis is used. The methodological focus attempts to demonstrate the usefulness of partial least squares structural equation modelling (PLS-SEM) in the research context. Covariance based structural equation modelling (CB-SEM) is more commonly used in the travel behaviour research; however PLS-SEM has gained popularity in the more recent times in other behavioural research fields such as informations systems, management and marketing. The findings highlight the importance of the spatial context in terms of the distance from Belfast city centre as a strong predictor of travel behaviour. This is complimented by the car-oriented attitude and the socio-economic influence. In contrast '*where we live*' is influenced by residential preferences, physical properties of the urban form and sustainable travel oriented attitudes.

**Key Words:** Urban form, Travel behaviour, PLS-SEM, Spatial Context, Attitude and Preferences.

**1. Introduction**

The influence of urban form on travel behaviour has been of particular interest to scholars and planners to achieve a broader goal of sustainable growth. Several factors influence this relationship ranging from physical urban form characteristics such as density [20,34,25], land use [24,19,17,30], accessibility [21], spatial context [27,28] etc. to the more subtle personal choices and preferences [35,37,38] at the individual level. These factors are further influenced by the socio-economic and demographic situation and some studies have reported the precedence of this over all other factors in terms of the strength of influence on travel behaviour [33,11,3]. The findings however do not reflect a general consensus in terms of the strength and influence of these relationships [5]. Thus further investigation and research is needed in this area [2] for robust conclusions.

The main interest is to understand whether urban form exerts any influence on travel behaviour and, if so, understand the mechanism of this relationship. Contextual differences

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are thus expected in terms of the mechanism of this relationship as behavioural patterns are strongly related to human perception. Although the vast literature on the relationship between urban form and travel behaviour can be broadly classified into two basic approaches – the physical context related approach and the person-centered approach [32], a third dimension also exists. It is the societal context that sets the backdrop for inter-relationship between urban form and travel behaviour [7]. Segregation and spatial dynamics has become a global phenomenon due to the impact of globalization, de-industrialization, restructuring and increasing income inequalities in our modern day society leading to spatial polarization [8,12,36]. This results not only in spatial segregation but deconcentration and decentralization which has a major impact on the urban spatial structure. Belfast presents one such case of spatial segregation where the socio-political legacy gave rise to the unique urban restructuring [8,12] which is beyond the scope of generalization for predicting the travel behaviour generated within it. This further strengthens the need for a more context specific research to examine the relationship between urban form and travel behaviour.

To sum it up, the abundance of studies still does not confirm an established general theory relating urban form and travel behaviour. Studies have also pointed at the need for a more holistic approach to explain the 'how' and 'why' of this relationship to identify specific land use and transportation policy for sustainable travel patterns [16,2].

In the field of travel behaviour research most studies have commonly referred to covariance based SEM (CB-SEM) as SEM [4,1,9,20,21,31] and the use of partial least squares SEM (PLS-SEM) is yet to be seen. One reason for this could be the ability of CB-SEM to test and confirm theory proposition where there is an established theory [13,23]. However the major concern lies in the lack of general consensus in terms of the validity and strength of this relationship [7]. For this reason a causal modelling approach which is exploratory in nature and yet has good predictive capabilities is more suited to the research problem. PLS-SEM was originally developed by Wold [39] as NIPALS (nonlinear iterative partial least squares) and further extended by Lohmoller [22] as an alternative to CB-SEM with less data constraints and more emphasis on the predictive capability [13]. It essentially combines several statistical techniques such as principal component analysis, multiple regression, multivariate analysis of variance, redundancy analysis and canonical correlations which are not a part of CB-SEM [23]. Also PLS-SEM is particularly useful in the case of models with higher third or fourth order constructs [23] which is helpful to theorize complex inter-relationship patterns. Thus structural equation modelling (SEM) is slowly becoming a quasi-standard in travel behaviour research with the dominance of the CB-SEM approach while the PLS-SEM approach remains less explored. While PLS-SEM has gained popularity in the more recent times in other behavioural research fields such as informations systems, management and marketing, it has yet to gain popularity in the field of travel behaviour research. Thus the study attempts to demonstrate the usefulness of PLS-SEM in the field of travel behaviour research.

This paper reports finding from a study conducted in Northern Ireland to understand the influence of urban form on travel patterns in the local context. The next section gives a brief overview of the study. This is followed the use of PLS-SEM and its suitability to the research problem. Section 4 discusses the materials and methods involved for the analysis of the research problem. The final section discusses these results and presents conclusions on the inter-relationship patterns influencing travel patterns in Northern Ireland.

## **2. The Study**

The main aim of this study is to explore the inter-relationships between urban form, attitude and preferences and travel behaviour to understand the mechanism of the relationships and the extent of influence of urban form in the Northern Ireland context. As travel stems from activity participation which is a resultant of individual decisions based on necessity and choices. This is influenced by the urban form both at the origin and destination since the need to participate in activities generates travel, the length and duration of which is dependent on the urban form [25]. Thus two specific issues are of concern to determine the inter-relationship patterns - firstly 'where we live' and secondly its impact on 'how we travel'.

This paper addresses these two questions adopting both a substantive and methodological approach. The substantive approach is to warrant a holistic approach to answer the 'how' and 'why' of the relationship between urban form and travel behaviour. For this a two prong approach involving both a qualitative exploration complimented with an exhaustive quantitative analysis is used. The qualitative survey was conducted using six focus group discussions and seventeen in-depth interviews involving a total of 53 participants. The findings were analysed using a grounded theory method to understand the important links between these factors. The results have been discussed elsewhere [5,6]. However the local relevance and importance of these factors have been used to inform the questionnaire design to further examine the issues that were of relevance in the Northern Ireland context. Following this an exhaustive questionnaire survey was conducted for the quantitative exploration of these findings in the three case study areas from which the 662 valid responses have been used in this study. For the travel diary, a total of 184 valid responses were received. The results from the travel diary analysis are not discussed here.

The methodological focus is to analyse the research problem using second generation multivariate analysis to better understand the causal relationships. Although travel behaviour research is dominated by studies using the covariance based SEM, referred to as SEM, by most of the studies, application of partial least squares SEM approach is yet to be seen. It has gained popularity in other behavioural research fields, for its soft modelling capabilities where the nature of the study is exploratory, the research objective is prediction, measures include formative constructs and the data is non-normal [13,23]. This study explores the usefulness of this modelling technique to analyse the research problem.

Thus study was particularly designed to (1) Explore the decision making process from the individual perspective on their travel patterns to identify the influential factors in the local context and understand their inter-relationship patterns, (2) Quantitatively analyse the relevance of each factor in influencing the travel patterns (3) Identify the mechanism of the relationship between urban form and travel behaviour. (4) Examine the direct and indirect relationships to identify the effective levels for policy information.

### **3. Materials and Methods**

Existing literature on the effect of urban form on travel behaviour have either emphasized on the qualitative aspect or on the quantitative association, the latter being more common. Rarely studies have used a combination of the two methods with the exception of a few [27]. This study embraces a similar combined approach using focus-groups, in-depth interviews, questionnaires and a seven day travel diary. In this paper we report the findings from the questionnaire survey informed by the focus group discussions and in-depth interviews. The aim of the quantitative analysis was to empirically establish the relevance of the factors influencing travel behaviour. Thus while the qualitative analysis added depth to the study the quantitative analysis adds the breadth to the findings for more robust conclusions. Smart PLS 2.0 M3 has been used [29] in this study for the empirical analysis. It is stand-alone specialized software for PLS path modelling. It operating system independent software built on the Java Eclipse platform [26].

#### **3.1 Selection of Case study areas**

The urban spectrum in Northern Ireland is defined in terms of the infrastructure provision. This gradation is divided into four bands [10], where three bands represent urban areas and the fourth represents the rural areas. The three case study areas have been selected to represent each of these three bands of the urban spectrum – level four represented by Ballynifeigh ward in Belfast, Level three represented by Knockmore ward in Lisburn and Level two represented by Banbridge West ward in Banbridge. This decision was also guided by macro-scale area descriptors at the electoral ward level (Density, Car ownership, Public transport network), which were used as indicators to select the case study areas using aggregate level secondary data. Case studies areas were selected by looking for maximum variations in the above criteria to minimise correlations between explanatory variables.

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Multiple deprivation unit measures were used to look for neighbourhoods in the middle band so that socio-economic conditions don't dominate and flaw the results. The final consideration for the selection was based on the varying distance of the three areas from the Belfast City centre to assess the influence of spatial structure on travel patterns. So while one area represented the inner-city area (Belfast), the other represented a suburb (Lisburn) and the third area represented the commuter town (Banbridge).

### **3.2 Data**

The study used a mix of qualitative and quantitative data. The focus group discussions and in-depth interviews for the qualitative analysis, were conducted between January and May 2013. Participants were mainly residents of the case study areas while the interviewees were mainly members of staff in the local councils, Government organizations and active community members. The aim of this exploration was to identify the major factors influencing travel behaviour in the Northern Ireland Context and also inform the questionnaire design.

The quantitative survey comprised of questionnaires and travel diaries collected between September 2013 and March 2014 from the three selected case study areas. To ensure a better response rate, an initial face-to-face contact was established at the householder's address by the researcher. A mutually suitable date and time was agreed for the collection. For collecting data from apartments especially in Belfast, a mail back strategy was used for these participants as it was not possible to gain access to individual doors for collection individually. A reminder note was left in their mailbox after a week requesting the participants to post back the questionnaires. This led to a fairly good response from the participants.

The valid response rate for the questionnaire survey in Belfast was 56.5%, for Lisburn it was 71% and finally in Banbridge a response rate of 69% was achieved.

### **3.3 PLS-SEM Model Building approach**

The study uses a hierarchical construct model to operationalize the complex inter-relationships between factors influencing travel behaviour. A total of 50 manifest variables have been used to construct their first order latent variables respectively. This forms the first stage of the hierarchical model which relates the observed variables to their latent construct. This is also called the outer model. The next step involves the second level of abstraction where these latent variables are used to define the second order latent constructs in the study. The inner model between the first order variables relating to the second order latent variables represents the second-order loadings. And finally the structural model comprising of the second order latent constructs is evaluated using the PLS path analysis. Every path in the structural model represents a direct relationship which is essentially a research hypothesis. These constructs and the related hypotheses are discussed below:

**Urban form Latent Constructs:** The urban latent constructs are the second order latent constructs comprising of the following first order latent constructs

1. *Neighbourhood properties:* This construct takes into account the physical properties of the urban form comprising of infrastructure, basic amenities and accessibility issues. We can broadly assume that as we go further out from the city centre the provision of infrastructure decreases. We therefore test the following hypotheses  
*H1-1: Neighbourhood property has a negative effect on travel behaviour.*  
*H1-2: Neighbourhood property is negatively related to the distance from the city centre.*
2. *Neighbourhood Quality:* This construct comprises of the human perception of the urban form aspect in terms of the attractiveness, safety issues, social interaction within the neighbourhood and the quality of space in terms of residential spaciousness offered by the urban form. Thus we test the following hypotheses  
*H2-1: Neighbourhood quality is positively related to travel behaviour.*  
*H2-2: Neighbourhood quality is positively related to the distance from the city centre.*
3. *Distance to the City centre:* As there is a Belfast centric approach in terms of investment and opportunities, this becomes particularly important for the daily commute trip lengths

involved from the suburbs and commuter towns. These spatial structural issues are important for improving regional connectivity. Thus we test the following hypothesis  
*H7: The distance to the city centre positively influences travel behaviour.*

**Attitude and Preferences constructs:** The attitude and perception construct took into consideration both attitude towards travel and preference for urban form type. They are discussed as below

4. *Car-Oriented:* This construct is operationalized by two first order constructs – pro-car attitude and the necessity of a car situation. The first construct is related to the mode perception while the other is related to the utility of the mode. Thus we can hypothesize  
*H3-1: Car-oriented attitude and preferences positively influences travel behaviour.*  
*H3-2: Car-oriented attitude positively influences the distance to the city centre.*
5. *Sustainable travel Oriented:* This construct takes into account the pro-public transport orientation and pro-active travel orientation such as walking and biking. It also takes into account the attitude towards travel minimising efforts such as trip chaining and using the nearest activity location for the activity purpose. Thus we hypothesize  
*H4-1: Sustainable travel-oriented attitude negatively influences travel behaviour.*  
*H4-2: Sustainable travel-oriented attitude is negatively related to distance to the city centre.*
6. *Residential Preferences:* This construct is operationalized using two latent constructs measuring the anti-urban sentiment and the strong social connections which are the important factors for choosing 'where to live'. Thus we hypothesize  
*H5-1: Residential preference positively influences travel behaviour.*  
*H5-2: Residential preference is positively related to the distance to the city centre.*

#### **Socio-economic and demographic construct**

7. *Socio-economic and Demographic:* This construct is a combination age, income, education, years lived in present address, number of cars in the household and number of driving license in the household information. This is important for segmentation based on demographics. Thus we test the following hypotheses  
*H6-1: SED positively influences travel behaviour.*  
*H6-2: SED is negatively associated with the distance to the city centre.*

## **4. Analysis and Results**

### **4.1 Sample Characteristics**

In general we find an even ratio of male female participants in all the three case study areas. The respondents also varied widely in terms of age with a greater portion of participants in the 30-49 years age bracket. As expected there is a greater percentage of households without children living in Belfast as city living was not found to be conducive to young family life. Also there are more households without a car in Belfast as compared to other areas. Lisburn has a higher percentage of multiple cars in household and availability of driving license. Another difference is the weekly travelled distance which is highest in Banbridge followed by Lisburn and the least in Belfast; in the order of diminishing distance from the Belfast city centre. Also home ownership was higher in Lisburn and Banbridge as compared to Belfast where the rental proportion was highest amongst the three. Another observation is the proportion of more educated and higher earning population living in Belfast as compared to the other case study areas. Since the study is interested in ascertaining the construct association, we refrain from a detailed descriptive analysis here.

### **4.2 Evaluation of the Measurement Model**

The study involves a combination of reflective and formative constructs. Thus separate evaluation of each type of measurement model is required.

For the reflective constructs, indicator reliability, convergent validity and discriminant validity needs to be established. The results shown in table 1 and 2 establish the measurement model's validity. For construct loadings of a minimum of 0.60 to 0.70 has been retained following the factor analysis of the outer model. For convergent validity, the model satisfied

the average variance extracted requirement of more than 0.50 and for composite reliability higher than 0.70. Finally discriminant validity was established as the results showed that the square root of the AVE was higher than the correlation with any other latent construct [13].

For formative constructs, while strong theory supported the construct validity, tests for multicollinearity satisfied the condition of VIF for the indicators to be less than 5 (<1.83 for all the formative indicators in this study).

<b>Table 1. FACTOR LOADINGS OF REFLECTIVE CONSTRUCTS FOR INDIVIDUAL ITEMS</b>			
	1ST ORDER CONSTRUCT	COMPOSITE RELIABILITY	AVE
1	Neighbourhood Accessibility	0.8155	0.5969
2	Neighbourhood PT Accessibility	0.9545	0.913
3	Neighbourhood Attractiveness	0.8232	0.5408
4	Neighbourhood Safety	0.8224	0.6072
5	Residential Spaciousness	0.796	0.6614
6	Pro-Car user	0.7568	0.5102
7	Pro-PT user	0.7802	0.5459
8	Pro-Active travel	0.8342	0.7164
9	Restraint measures	0.8244	0.7018
10	Anti-urban sentiment	0.6983	0.4427
11	Social connections	0.767	0.6319
<i>Note: AVE should be &gt;0.50</i>			
<i>Composite Reliability should be &gt; 0.70</i>			

<b>Table 2. INTER-CONSTRUCT CORRELATIONS AND THE SQUARE ROOT OF AVE</b>											
	ANTIURBAN	NBHACCS	NBHATTR	NBHPTACS	NBHSFTY	PARKREST	PROACTIV	PROCAR	PROPT	RESSPACE	SOCCONNEC
ANTIURBAN	<b>0.6654</b>										
NBHACCS	-0.0551	<b>0.7725</b>									
NBHATTR	0.0866	0.2154	<b>0.7354</b>								
NBHPTACS	-0.1619	0.4116	0.0425	<b>0.9555</b>							
NBHSFTY	0.1477	0.1149	0.5059	-0.0866	<b>0.7792</b>						
PARKREST	0.0534	0.0526	0.0195	0.1171	-0.013	<b>0.8377</b>					
PROACTIV	-0.0454	0.0546	0.0555	0.2353	0.0121	0.0576	<b>0.8464</b>				
PROCAR	0.0421	0.0718	0.0246	-0.1968	0.0987	-0.0287	-0.1895	<b>0.7143</b>			
PROPT	-0.1334	0.0302	0.0617	0.3339	-0.03	0.1475	0.265	-0.2905	<b>0.7389</b>		
RESSPACE	0.1968	0.1181	0.307	-0.0934	0.2581	0.0303	-0.1116	0.0797	-0.0401	<b>0.8133</b>	
SOCCONNEC	0.1047	0.0397	0.1019	-0.0188	0.1174	-0.017	-0.0556	0.1308	-0.0657	0.1906	<b>0.7949</b>

#### 4.3 Evaluation of the Structural Model

As the objective of the PLS-SEM is prediction, the primary evaluation criteria comprises of the  $R^2$  measures and the significance of the path co-efficients [13]. Thus high  $R^2$  values are desirable. However high  $R^2$  values are research domain specific with 0.20 considered high in the field of consumer behaviour, while in marketing research and success driver studies 0.75 is considered high [13]. In the field of travel behaviour research, scholars have commented on the  $R^2$  values rarely exceeding 0.30 [18]. Others have noted the relatively low  $R^2$  values in the region of 0.20 – 0.25 for studies studying the effect of urban form and attitude factors on travel behaviour [15].

Our model has achieved a  $R^2$  value of 0.27 for travel behaviour and 0.2 for the distance to the city centre, which can be considered substantial owing to the relatively low  $R^2$  values observed in this field of research. Fig 1 shows these results.

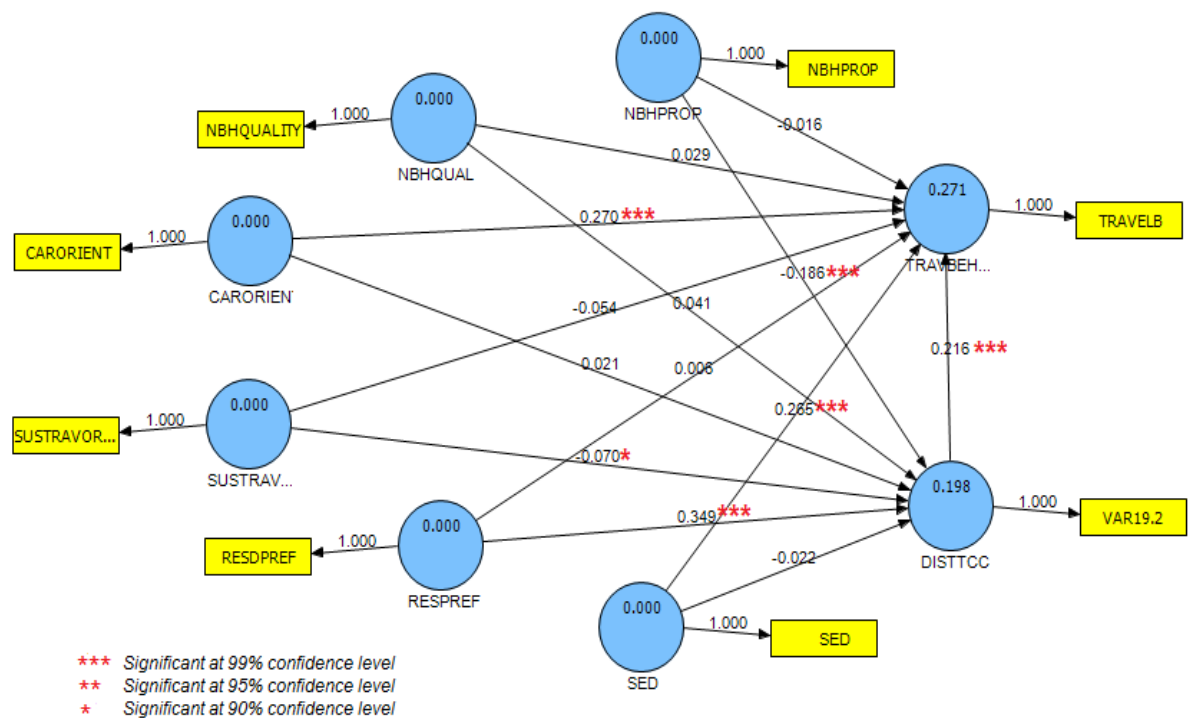


Figure 1: Structural model evaluation showing path co-efficients.

Next, to assess the significance of the path co-efficient, bootstrapping is performed. As PLS-SEM does not assume multivariate normality, parametric significance tests are not applicable to test if the co-efficients such as outer weights and loadings are significant. Thus PLS-SEM uses the non-parametric bootstrapping procedure to test the significance of these co-efficients [13]. The recommended minimum number of bootstrap sample of 5000 is performed. The results have been presented in table 3. The significance test helps to support or reject the research hypotheses as every path in the structural model is essentially a direct relationship between the latent constructs representing a theoretical proposition.

Table 3. RESULTS OF HYPOTHESIS TESTING				
HYPOTHESIS		PATH COEFFICIENT	T VALUE	SUPPORTED?
Hypothesis H1-1	NBHPROP → TRAVBEHAV	-0.016	0.375	No
Hypothesis H1-2	NBHPROP → DISTTCC	-0.186	4.218***	Yes
Hypothesis H2-1	NBHQUAL → TRAVBEHAV	0.029	0.767	No
Hypothesis H2-2	NBHQUAL → DISTTCC	0.041	0.98	No
Hypothesis H3-1	CARORIENT → TRAVBEHAV	0.27	7.027***	Yes
Hypothesis H3-2	CARORIENT → DISTTCC	0.021	0.46	No
Hypothesis H4-1	SUSTRAVORIENT → TRAVBEHAV	-0.054	1.349	No
Hypothesis H4-2	SUSTRAVORIENT → DISTTCC	-0.07	1.732*	Yes
Hypothesis H5-1	RESPREF → TRAVBEHAV	0.006	0.147	No
Hypothesis H5-2	RESPREF → DISTTCC	0.349	8.766***	Yes
Hypothesis H6-1	SED → TRAVBEHAV	0.265	7.264***	Yes
Hypothesis H6-2	SED → DISTTCC	-0.022	0.537	No
Hypothesis H7	DISTTCC → TRAVBEHAV	0.216	5.428***	Yes
Note: These significance levels are obtained by bootstrapping				
*** Significant at 99% Confidence level				
** Significant at 95% Confidence level				
* Significant at 90% Confidence level				



#### 4.4 Predictive Validity of the Structural model

Finally the model's capability to predict is tested using the Stone-Geiser's  $Q^2$  test. This test postulates that the model should be able to predict the endogenous latent construct's indicators adequately [13]. This is done by using the blindfolding technique included in the SmartPLS software. If this cross validity redundancy measure value ( $Q^2$ ) is greater than 0, for the endogenous construct, then its explanatory latent constructs are said to have predictive relevance [13]. Our model has also fulfilled this criterion and the results of the Stone-Geiser's  $Q^2$  test have been reported in table 4.

<b>Table 4. PREDICTION RELEVANCE TEST (Stone-Geisser's <math>Q^2</math> test)</b>			
Endogenous Construct	SSO	SSE	$Q^2$
DISTCC	662	529.8876	0.1996
TRAVBEHAV	662	510.8695	0.2283
<i>Note: For predictive relevance <math>Q^2</math> Value should be <math>&gt; 0</math></i>			

#### 5. Conclusion

The model highlights the importance of the spatial context of urban form in terms of the distance from Belfast city centre as a strong predictor of travel behaviour. Studies have reported such findings from other geographical context [27,28]. This urban form construct is more influential than the neighbourhood-scale characteristics. As travel behaviour is operationalised by vehicular miles travelled, we can conclude that suburban or commuter town living is associated with longer vehicular travel distances. However there is a direct and significant negative influence of the neighbourhood properties on the distance to the city centre. This is true in the sense that the provision of urban infrastructure, amenities and accessibility measures decreases as we go down the urban spectrum. Therefore there is a major trade-off between choosing to live in suburban or commuter town locations and the level of facilities and accessibility, especially in terms of public transport. This automatically translates into car dependency and longer travel distances to access activity locations. While these observations were quite expected we now see the role of attitude and preferences in shaping these patterns.

We find that the car-oriented attitude has a significant influence on travel behaviour. The disposition of a car would definitely lead to more usage of it. While affordability is a determinant of car availability, the qualitative study revealed the role of perception as a major concern. Without changing the perception of car dependency, public transport investment may not necessarily increase the ridership. Soft policy measures coupled with integrated land-use transport measures, may prove useful to change this car-oriented lifestyle.

In comparison to the car dependency, the sustainable travel orientation is significantly related to the distance from the Belfast city centre but only at a 90% confidence level. The lesser relevance maybe due to the decreasing level of public transport and cycling lane provision and almost non-existent outside the city limits as commented by participants in the in-depth interviews and focus group discussions. So we find that sustainable travel orientation is a more citywide phenomenon and less applicable outside the city realm due to the absence of the requisite infrastructure to encourage such pursuit. Increasing the land use diversity and promoting sustainable transport provision and infrastructure in new developments may prove effective to encourage sustainable travel behaviour.

The residential preference again exerts a strong influence on the distance to the Belfast city centre. This reflects the strong anti-urban sentiments of the population. The ethno-national conflicts have played an important role in instilling anti-urban lifestyle preferences due to outmigration and decentralization from the city core. Also the relatively compact geographical extent of Northern Ireland complimented with an overgenerous share of road infrastructure has allowed for this type of residential-preference as commute distances are still within reasonable distance and time. Also factors associated with residential preferences are strong social connections with family and friends and familiarity with an area, which plays an important role in choosing 'where to live'. While this problem may seem less easy to



address in terms of policy intervention, the growth of commuter towns along major road network offer a solution. These commuter towns have a fairly high density (eg Banbridge has a higher density than Lisburn which is a suburb) and provides the opportunity to be close to the social sphere and yet be able to enjoy urban infrastructure provisions and commute to work efficiently. This provides a case for the reverse of transit-oriented development where mass transit provision need to be provided to cater to these developments and create a transit corridor. Thus enhancing the transit opportunities in these areas may lead to more sustainable travel patterns.

Finally we find another strong relationship - the influence of socio-economic and demographic status of the sample population on travel behaviour. More affluence results in more car ownership which in turn leads to more vehicular miles travelled. Thus this observation is quite expected, the reason why this is used as a control in the study.

Thus we may conclude that the relationship between urban form and travel behaviour involves complex inter-relationships for which single equation first generation techniques are not sufficient. Structural equation modelling provides a useful tool to simultaneously evaluate these relationships. Although the dominance of the covariance based SEM is found in the field of travel behaviour research, there are no reasons for not using the less used partial least squares approach depending on the suitability to the research problem. Scholars have commented on the two approaches as complementary, as in general the weaknesses of CB-SEM are the strengths of PLS-SEM and vice versa [14]. Thus the pedagogical focus of the study for the adoption of PLS-SEM in the field of behavioural research is an important contribution. Further research can extend these analyses to test for mediation and moderation effects involved in the relationship between the urban form constructs and travel behaviour.

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